

TRANSPORT MECHANISM

Singer - Nicolson Model or Fluid Mosaic Model (1972)

- Seymour J. Singer and Garth L. Nicolson
- The cell membrane is a mosaic of proteins that are embedded or attached to a fluid bilayer of protein. (phospholipid, proteins, cholesterol)
- The fluidity of a cell membrane depends on the lipid composition of the membrane, the density of integral proteins, and the temperature. The fatty acids and cholesterol play an important role in the fluidity of the cell membrane.

2 Mechanisms for Transport Across Cell Membranes

1. Passive Transport
2. Active Transport

1. Passive transport

- is the movement of substances across membranes without energy expenditure.

Forms of Passive Transport

1. *Simple Diffusion* - The tendency of ions, food, and other dissolved substances to move from an area of high concentration to an area of low concentration until the concentration is equal across a space

2. *Osmosis* - The movement of water across a porous membrane from a dilute solution to a more concentrated solution

- Tonicity describes the concentration of solute inside and outside the cell and how it affects the volume of the cell. Osmolarity describes the concentration of solute of the solution.

- To describe how the principles of osmosis and tonicity apply to cells, three physiological solutions must be considered: If the solute concentration of the solution is greater than that of a cell (**hypertonic** solution), water will move out from the cell, causing the cell to shrink. Conversely, if the solute concentration is less than that of a cell (**hypotonic** solution), water will tend to move into the cell, causing it to expand, and even burst. However, if the solute concentration is equal to that of a cell

(**isotonic** solution), then there will be no net water movement.

3. *Facilitated Diffusion* - The tendency of ions, food, and other dissolved substances to move from an area of high concentration to an area of low concentration with the help of membrane proteins

2. Active Transport

- is the means of moving substances across a membrane which requires the expenditure of energy, usually in the form of adenosine triphosphate (ATP), through the transport proteins called carrier proteins.

Types of Active Transport

1. *Primary active transport* - The movement of ions across a membrane which creates a difference in charge across that membrane

2. *Secondary active transport* - The movement of biomolecules like amino acids and glucose across a membrane which is driven by primary active transport of ions such as sodium, potassium, and calcium.

3. *Bulk transport* - Larger molecules and particles are encased in vesicles to enter or leave the cell which requires the expenditure of cell's energy. They need to move across the membrane in bulk because it is impossible for them to pass through directly to the membrane even with energy supplied by the cell.

2 Types of Bulk transport

1. Endocytosis
2. Exocytosis

1. Endocytosis

- is the process by which a cell membrane invaginates and forms a pocket around a cluster of molecules. This pocket pinches off and forms a vesicle that transports the molecules into the cell.

Types of Endocytosis

1. *Phagocytosis* - known as "cell eating", the type of endocytosis through which a cell takes in food particles

2. *Pinocytosis* - known as “cell drinking”, the type of endocytosis by which a cell absorbs small particles outside and brings them inside.

3. *Receptor-mediated endocytosis* - the obtaining of substances by the cell which targets a single type of substance that binds to the receptor on the external surface of the cell membrane

2. Exocytosis

- The process of removing waste materials from the cell into the extracellular fluid

5 Cell Membranes Components

1. *Phospholipid* - Main fabric of the cell membrane

2. *Cholesterol* - Maintains the integrity and fluidity of the cell membrane; dampens effects of temperature

3. *Integral proteins* - Transport substance through cell membrane; function as receptors; for cell adhesion; for structural support

4. *Peripheral proteins* - Function to transmit and recognize signals to and from the external environment

5. *Carbohydrates* - Transmit and recognize signals to and from the external environment; serve as an effective interaction with the aqueous environment

THE CELL

- The **cells** are the **basic/ functional units of life**, in which all of the chemical reactions necessary for the maintenance and reproduction of life take place. All living things are made up of cells. Some organisms consist of only one cell. Plants and animals are made up of many cells. The human body has more than **100 trillion** (10,000,000,000,000) cells.
- All cells have some things in common, whether they are specialized cells or one-celled organisms. A cell is alive. It “breathes”, takes in food, and gets rid of waste. It also grows and reproduces

(creates its own kind). And, in time, it dies.

- A **cell** is **the smallest unit** that is capable of performing life functions.

Early Microscopy and Observations

- **Before microscope**, the **Romans** had already invented and experimented with glasses during first Century.
- Became the early form of **lens** (Latin word: **Lentil**)
- One of these glass samples involved a piece that had thick middle and thin edges. They discovered the small samples become larger when viewed through this glass sample.
- These were not fully utilized until 13th century when they finally used in eyeglasses production.
- **Roman philosopher, Seneca**, who described, “**letters could be magnified by a ball of crystal**” glass globe of water to magnify text in order to read books.
- In **1590**, **Dutch spectacle-maker Zacharias Janssen** made the first compound microscope (one having more than one lens to magnify the image that can magnify an image 30 times). It was believed that he had help from his father, Hans Janssen.
- In **1665**, **Robert Hooke**, a *British scientist*, examined the structure of thinly sliced cork under the microscope and described small rectangular compartments which he called **cellulae** (Latin for **small chambers/rooms** reported in his publication **Micrographia**.)
- In **1676**, **Anton van Leeuwenhoek**, a *Dutch shopkeeper*, he made his own microscope to examine the fabric he is buying (fabric merchant)
 - o He examined pond water sample and saw living organisms (protozoa and fungi), which he called **animalcules** (small animals).
 - o His **single-lenses** magnified an image **200 times**.
 - o He was also the **first scientist to observe sperm cells and egg cells** of both animals and humans.

He discovered that they undergo fertilization which disproved **the theory of spontaneous generation**.

Development of the Cell Theory

- In **1838**, **Matthias Schleiden**, a *German botanist*, determined that all living plant tissue was composed of cells and that each plant arose from a single cell.
- In **1839**, **Theodore Schwann**, a *German zoologist* came to a similar conclusion to animals.
- In **1858**, the cell theory was refined by *German pathologist* **Rudolf Virchow**, who concluded that “all cells arise from cells” and that the cell was the basic unit of life.
- This discovery was initially made by **Robert Remak** in **1855** when he tried to prove the idea of cell division

3 Postulates of Cell Theory

The combined works of **Schleiden**, **Schwann**, **Virchow** and Remak makes up what is now known as the **Cell Theory**.

1. All organisms are made up of cells

Schleiden (a *botanist*) and **Schwann** (a *physiologist*), both separately concluded that cells are the basic structural as well as functional units of all living organisms. While Schleiden specifically *studied plant tissues* and proposed that all *plants* are composed of cells, Schwann extended this idea to *animal cells*, suggesting that all *animal tissues* are also made up of cells. Their combined observations led to the realization that **cells are the building blocks of life**.

2. The cell is the basic unit of life. (speaking both structurally as well as functionally)

Both Schleiden and Schwann recognized that cells are *not just static units* but are also essential for organismal functions. Cells carry out **specific functions and activities necessary for life** and the overall structure and function of an organism depend on the interactions and activities of its cells. Energy flow occurs within all cells.

3. Cells arise from pre-existing cells.

Both scientists observed that cells did not arise spontaneously but instead **originated from the division of pre-existing cells**. This concept, known as *cell division or cell reproduction*, is a fundamental process in biology and is central to the growth, development, and reproduction of all living organisms.

PROKARYOTES vs. EUKARYOTES

1. Prokaryotes

- Are predominantly **single-celled organisms** classified in the domains: *Bacteria* and *Archaea*.
 - Archaea (**salty** environments) are known as **halophiles**.
 - Archaea (**extremely hot** environments) are called **thermophiles**.
 - Archaea (produce **methane**) are called **methanogens**.
 - Archaea are known for living in extreme environments, but they also can be found in common environments, like soil.
- All prokaryotes **have plasma membranes, cytoplasm, ribosomes, a cell wall, genetic material**, and lack membrane-bound organelles.
- Prokaryotic cells range in diameter from **0.1-5.0 µm**.
- Prokaryotes were the **first form of life**.
- In prokaryotic cells, **DNA bundles together** in a region called the **nucleoid**.
- In prokaryotes, molecules of *protein, DNA and metabolites* are all found together, **floating in the cytoplasm**. Primitive organelles, found in bacteria, do act as micro-compartments to bring some sense of organization to the arrangement.

Prokaryotic Cell Features

Nucleoid: A central region of the cell that contains its DNA.

Ribosome: Ribosomes are responsible for protein synthesis.

Cell wall: The cell wall provides structure and protection from the outside environment. Most bacteria have a rigid cell wall made from carbohydrates and proteins called peptidoglycans.

Cell membrane: Every prokaryote has a cell membrane, also known as the plasma membrane, that separates the cell from the outside environment.

Capsule: Some bacteria have a layer of carbohydrates that surrounds the cell wall called the capsule. The capsule helps the bacterium attach to surfaces.

Fimbriae: Fimbriae are thin, hair-like structures that help with cellular attachment.

Pili: Pili are rod-shaped structures involved in multiple roles, including attachment and DNA transfer.

Flagella: Flagella are thin, tail-like structures that assist in movement.

2. Eukaryotes

- A eukaryotic cell **has a plasma membrane, cytoplasm, and ribosomes.**
- Eukaryotic cells are typically much larger than prokaryotic cells (**10-100µm**) and have a true **nucleus** and other **membrane-bound organelles** that allow for compartmentalization of functions.
- Scientists believe that **eukaryotes evolved from prokaryotes** around **2.7 billion years ago.**
- Organelles are internal structures responsible for a variety of functions, such as **energy production and protein synthesis.**
- While **most** eukaryotes are **multicellular organisms**, there are **some single-cell eukaryotes.**
- The **nucleus** is where eukaryotes **store their genetic information.**

All cells, whether **prokaryotic or eukaryotic**, share these 4 features:

1. DNA

2. Plasma membrane

3. Cytoplasm

4. Ribosomes

PROKARYOTE

Nucleus: Absent

Membrane-bound organelles: Absent

Cell structure: Unicellular

Cell size: Smaller (0.1-5 µm)

Complexity: Simpler

DNA Form: Circular

Examples: Bacteria, archaea

EUKARYOTE

Nucleus: Present

Membrane-bound organelles: Present

Cell structure: Mostly multicellular; some unicellular

Cell size: Larger (10-100 µm)

Complexity: More complex

DNA Form: Linear

Examples: Animals, plants, fungi, protists

CELL STRUCTURE AND FUNCTIONS

Cell Membrane

- The cell membrane is a structure that **forms the outer boundary** of the cell and allows only certain materials to **move into and out** of the cell.
- Food, oxygen and water move into the cell through the membrane. Waste products also leave through the membrane.
- Separates cell from external environment.

Cytoplasm

- Is the **gel-like material** inside the cell membrane and outside the nucleus.
- Enclosed within the cell membrane and contains the **semifluid substance** called **the cytosol**
- Within the cytosol are diff substances such as electrolytes (substances that produce electrically conducting solutions, metabolites (substances during metabolism), RNA and synthesized proteins.

Cytoskeleton

- **Cytoplasm have structure** due to the presence of the cytoskeleton
- Contains small microfilaments and larger microtubules.
- They support the cell, giving it its shape and help with the movement of its organelles.
 - o *Microfilament (7 nanometer)*
 - o *Intermediate Filament (8 to 10 nm) - the most stable and least soluble and provide tensile strength (Tensile strength refers to the maximum stress*

that an object can withstand before it breaks)

- o *Microtubules* (25 nm) - are small hollow tubes. The wall of the microtubule is made polymerized dimers of α -tubulin and β -tubulin, two globular proteins.
- Are also structural elements of flagella, cilia and centrioles.

Centrosome

- A microtubule organizing structure found **near the nuclei of animal cell** and contains a pair of centrioles
- During cell division, the **microtubules arrange** themselves in a specific manner **to form centrioles**.
- Centrioles help in the separation and movement of the replicated genetic materials called chromosomes to opposite poles.

Nucleus

- The **largest organelle** in the cytoplasm of a eukaryotic cell is usually the nucleus, a structure that directs all the activities of the cell and most of the genetic processes takes place in here.
- **Control center** of the cell
- The **nuclear envelope** is the **boundary of the nucleus**, which composed of inner and outer nuclear membranes. In **between is the perinuclear membranes**.
- Chromatin strands further condense to form chromosomes during cell division. Substances that move in and out of the nucleus pass through the nuclear pores.

Nucleolus

- **Membrane-free organelle** found inside the nucleus that **contains fibrils and granules**.
- **Fibrils have DNA** coding for ribosomal RNA (rRNA). The granules contain rRNA molecules with proteins coming from the cytoplasm.
- The nucleolus is important in **creating the ribosomes** which are the sites of protein synthesis.
- The absence of the nucleolus will compromise the process of protein

production because there is none that can produce the ribosome.

Ribosomes

- **Small non-membrane bound** organelles.
- Contain two sub units
Site of protein synthesis: Protein factory of the cell. Some proteins serves **as enzymes**.
- Either **free floating or attached to the Endoplasmic Reticulum**.

Mitochondrion

- The **powerhouse** of the cell
- Organelles work with the mitochondrion. The **food broken down** by the lysosomes may be **converted to ATP** by the mitochondrion. Also, the ATP produced by the mitochondrion may be used to perform primary active transport in the cell membrane, as well as flagellar movement.

THE ENDOMEMBRANE SYSTEM

- **Endo = "within"** a group of membranes and organelles in eukaryotic cells that works together to change, package, and transportation of lipids and proteins.
- This is a group of membranes and organelles in eukaryotic cells that works together to **modify, package, transport lipids and proteins**.
- It includes the **nuclear envelope, lysosomes, and vesicles, endoplasmic reticulum, golgi apparatus, and plasma membrane**.

Endoplasmic reticulum (ER)

- The Endoplasmic Reticulum (ER) is a **folded membrane** that moves materials around in the cell. The ER extends from the nucleus to the cell membrane and takes up quite a bit of space in some cells.
- The ER is like **a system of conveyor belts** in a business. They act **as tunnels** in which materials move from one place to another within the cell.
 - o **Rough Endoplasmic Reticulum** - Ribosomes attached to surface

- o **Smooth Endoplasmic Reticulum**
- No attached ribosomes

Golgi Body/Golgi Complex/Golgi Apparatus

- **Modifies, packages and distributes** molecules made at one location of the cell and used at another.
- Golgi bodies **work closely with ER**. The substance produced in the ER (Protein) enters its lumen. The substance then **pinches off** to become vesicle.
- The vesicle **moves toward the cis face**. The golgi bodies can modify the substances in the vesicle by **putting "tags"** so that the substances will be recognized and accepted in their respective destinations. Once ready, the vesicles containing the modified substance **exit at trans face**.

Lysosome

- It has **hydrolytic enzymes** (protein that use water to break down substances) – digest food, recycle old components of the cell, and kill invading micro-organisms.
- The digested food and recycled components are released into the cytosol to be used by the cell. The **indigestible food stays** in the lysosomes which eventually **become residual bodies**. Residual bodies can be **eliminated by exocytosis**.
- The lysosomal membrane contains a special carbohydrate covering its inner surface. This prevents the lysosome from releasing the hydrolytic enzyme all at once. If this happens, the cell may be killed. This is why the lysosome is called the **"suicide bag"** of the cell.

Peroxisomes

- These are **small, round organelles enclosed in single membranes**. They carry out **oxidation reactions** that **break down fatty acids and amino acids**. They also detoxify many poisons that may enter the body.
- Many of these oxidation reactions release **hydrogen peroxide**, H₂O₂, which would be damaging to cells; however, when

these reactions are confined to peroxisomes, enzymes safely break down the H₂O₂ into oxygen and water.

Vesicles and Vacuoles

- These are **membrane-bound sacs** that function in **storage and transport**.
- **Vacuoles** are somewhat **larger than vesicles**.
- The **vacuole does not fuse** with the membranes of other cellular components.
- The membranes of **vesicles can fuse** with either plasma membrane or other membranes within the cell.

Flagella and Cilia

- Appendages responsible for **locomotion** of cells.
- The **locomotive action** is due to the **arrangement of microtubules**.
- Both **have a central core** called **anoxeme**, which is surrounded by an extension of the cell membrane.
- In humans, flagella and cilia are **important in reproduction**.

Cilia

- **Short**
- Used to move substances outside human cells
- In females, the cilia in the fallopian tube **help move the egg or embryo** toward the uterus.

Flagella

- **Whip-like extensions**
- **Found on sperm cells**
- Sperm have flagella to enable them **to swim**. It uses its **flagellum to swim** to reach the egg.

Cell Wall (plant)

- Located **outside the cell membrane, made of cellulose**
- **Cellulose** is a **polysaccharide**, composed of **long chain of carbohydrates**.
- The cell wall is a **rigid structure** outside the cell membrane that supports and protects the cell.

Chloroplast (plant)

- Chloroplasts **contain a green pigment** called **chlorophyll**. This is what makes plants green.
- Chloroplasts **take in sunlight, water and carbon dioxide** to make oxygen and sugar (a form of food) called **photosynthesis**

Central Vacuole (plant)

- Vacuoles **store water, food, pigments, waste or other materials**
- Animals and plants have vacuole but the vacuoles in the latter are usually larger and are thus observed more easily when viewed under microscope.
- In most mature plant cells, the vacuole that occupies the **largest space** is called **central vacuole**. The central vacuole is **surrounded by a membrane** called **tonoplast**.
- **Turgor Pressure** is the pressure exerted onto the cell wall by **water moving into the cell**. The central vacuole contains a higher solute concentration than the cell's environment. Because of this, the water tends to move toward the cell, making the cell swell and maintain the turgor pressure. When **turgor pressure is lost, the cell wilts**. Thus the entire plant wilts.

Peptidoglycan (Bacteria)

- Composed of **amino acids and sugars**
- This **gives the cell walls of the bacteria structure** and **provides protection**
- **Chitin (Fungi)**
- **Nitrogen-containing polysaccharide** similar to cellulose which serves as structural support.

CELL TYPES (PLANT /ANIMAL TISSUE)

Histology - Study of tissues

Hierarchy of Biological Organization -

The biological levels of organization of living things arranged from the simplest to most complex.

Atom → Molecule → Cell Organelles → Cell → Tissue → Organ → Organism → Population → Biocenosis → Ecosystem → Bioma → Biosphere

ANIMAL TISSUES

4 Types of Animal Tissue

- 1. Epithelial Tissue**
- 2. Connective Tissue**
- 3. Muscle Tissue**
- 4. Nervous Tissue**

1. EPITHELIAL TISSUE

- All layers and organs in the body are lined by a group of tissues called epithelial tissues which are commonly referred to as **epithelium**.
- They **cover the surface of all internal as well as external organs**.
- They line **body cavities and hollow organs**, and are the **major tissue in glands**.
- Epithelial tissue is **highly permeable**. Thus, it plays a significant role in the exchange of substances across the cells and helps in maintaining the osmoregulation. Depending on the number of layers of cells it is composed of the epithelium has been divided into the simple epithelium and compound epithelium.

7 Functions of Epithelium

1. Protection: Epithelial tissue protects several aspects of your body. For example, your skin is made up of epithelial tissue and protects the tissues deeper in your body, such as blood vessels, muscle and internal organs. The cilia on the epithelial cells that line your intestines protect the rest of your body from intestinal bacteria.

2. Secretion: Epithelial tissue in your glands (glandular epithelium) can secrete (release) enzymes, hormones and fluids.

3. Absorption: The epithelial lining of your internal organs, such as your liver and lungs, can allow the absorption of certain substances. For example, the internal epithelial lining of your intestines absorbs nutrients from the food you eat.

4. Excretion: Excretion is the removal of waste from your body. The epithelial tissue in your kidneys excrete waste, and the

epithelial tissue in your sweat glands excrete sweat.

5. Filtration: The epithelium of your respiratory tract filters out dirt and particles and cleans the air that you breathe in. Epithelial tissue in your kidneys filters your blood.

6. Diffusion: In biology, diffusion is the passive movement of molecules or particles from regions of higher concentrations to regions of lower concentration. Simple squamous epithelial cells form a membrane that allows selective diffusion of materials to pass through. Diffusion helps with filtration, absorption and secretion functions.

7. Sensory reception: Sensory nerve endings that are embedded in epithelial tissue allow your body to receive outside sensory stimuli. As an example, the stereocilia on the surface of the epithelial tissue in your ear are essential for hearing and balance. In addition, your taste buds are embedded in the stratified squamous epithelium of your tongue.

7 Types of Epithelial Tissues

1. Simple Squamous Epithelium

- Found in air sacs of lungs and the lining of the heart, blood vessels, lymphatic vessels.
- This type of epithelium typically regulates the passage of substances into the underlying tissue.
- Allows materials to pass through by diffusion and filtration, and secretes lubricating substance.

2. Simple Cuboidal Epithelium

- Found in ducts and secretory portions of small glands and in kidney tubules
- Secretes and absorbs

3. Simple Columnar Epithelium

- Ciliated tissues are in bronchi, uterine tubes and uterus; smooth (non-ciliated tissues) are in the digestive tract, bladder
- These cells line your stomach and intestines.

- It helps in the directional movement of materials along with the hollow organs like the respiratory tract.
- The cuboidal or columnar epithelia which are specialized in secretions are called glandular epithelium which includes the exocrine and endocrine glands.
- Absorbs; it also secretes mucous and enzymes

4. Pseudostratified Columnar Epithelium

- Ciliated tissues line the trachea and much of the upper respiratory tract
- Secretes mucous; ciliated tissue moves mucus

5. Stratified Squamous Epithelium

- Lines the esophagus, mouth, and vagina
- Outer layer of skin (epidermis)
- Being tightly packed, tight junctions serve as barriers for pathogens, mechanical injuries, and fluid loss.
- This type of epithelium usually has protective functions, including protection against microorganisms from invading underlying tissue and/or protection against water loss. The outer layer of your skin (the epidermis) is made of stratified squamous epithelial cells.

6. Stratified Cuboidal Epithelium

- This type of epithelium is not as common and is found in the excretory ducts of your salivary and sweat glands
- Protective tissue

7. Stratified Columnar Epithelium

- The male urethra and the ducts of some glands
- Rare type of epithelium and is seen in the mucous membrane (conjunctiva) lining your eyelids
- Secretes and protects

3 Epithelial Cell based on Specialized Functions

1. Transitional Epithelium

2. Glandular Epithelium

3. Olfactory Epithelium

1. Transitional Epithelium

- Lines the bladder, urethra and the ureters

- (also known as urothelium) is made up of several layers of cells that become flattened when stretched. It lines most of your urinary tract and allows your bladder to expand.

2. Glandular Epithelium

- Glands
- This type of epithelium is specialized to produce and secrete (release) substances. It's found in your glands, which are specialized organs that can make, store and/or release substances such as hormones, proteins and water.

3. Olfactory Epithelium

- Nasal cavity
- The olfactory epithelium contains olfactory receptor cells, which have specialized cilia extensions. The cilia trap odor molecules you breathe in as they pass across the epithelial surface. Information about the molecules is then transmitted from the receptors to the olfactory bulb in your brain, where your brain then interprets the smell.

2. CONNECTIVE TISSUE

- They **connect and support** the different tissues, organs, and parts of the body.
- Among the animal tissues, connective tissues are the **most abundant** ones in the body.
- The connective tissue cells are freely arranged in a matrix and are widely distributed in the body.

Areolar Tissue

- a loose connective tissue that can be seen between the skin and muscles; in the bone marrow as well as around the blood vessels and nerves.
- fills the spaces between the different organs and connects the skin to the underlying muscles.
- it provides support to the internal organs as well as help in the repair of tissues.

Adipose Tissue (Fat)

- It is present in skin and organs.
- The areolar tissue consists of many types of fibres and cells. Among the cells are

the adipocytes. These adipocyte cells together make the adipose tissue or the fat tissue. It is in these cells that fat is stored in the form of fat globules. Due to the storage of fat, the adipose tissue acts as an insulator.

Blood

- Blood is a fluid connective tissue. It consists of a liquid matrix called the plasma, in which blood cells are present. So it can be said blood is an important lifeline. It travels all around the body in specialized blood vessels. Blood has many functions to play in the body. Primarily, it helps in the transport of gases, nutrients, hormones as well as the elimination of the waste materials.
- There are three types of blood cells that are found in the plasma. They are the Red blood cells (RBC) or Erythrocytes; White blood cells or Leucocytes (WBC) and Thrombocytes or Blood Platelets. The RBCs and the WBC's are the living components of the blood.
- The RBCs have a pigment called hemoglobin, due to which blood appears red in colour. The WBCs help in protecting the body by attacking any foreign body that enters into the body, while the blood platelets are responsible for clotting of blood.

Bone

- Bone is a hard connective tissue which forms the framework of the body.
- It has a rigid matrix rich in calcium and collagen fibers.
- Functions include protection, support, facilitates movements and serves as a site for blood cell production.

Cartilage

- Cartilage is another type of connective tissue that has a solid matrix.
- It contains proteins and sugars.
- The cartilage tissue has widely spaced cells.
- Cartilage is also an important connective tissue as it helps in smoothening the bone surfaces at the joints.

- Cartilage is also present in the trachea, nose, ears, and larynx.

3. MUSCLE TISSUE

- These tissues are **composed of long cells** called **muscle fibers** that allow the body to **move voluntary or involuntary**.
- Movement of muscles is **a response to signals** coming from nerve cells.
- In vertebrates, these muscles can be categorized into the following:
 - o **Smooth** - not striated; involuntary, these help in peristalsis and other involuntary functions of the body.
 - o **Skeletal** - striated; voluntary movements, provide support, help in movement and maintain homeostasis
 - o **Cardiac** - striated with intercalated disk for synchronized heart contraction; involuntary, it helps in blood circulation and keeps the heart pumping

4. NERVOUS TISSUE

- Nervous tissue **makes up the peripheral and the central nervous system**. It develops from the **ectoderm of the embryo**. It possesses the ability to initiate and transmit the nerve impulse. Its main components include:
- These tissues are **composed of nerve cells called neurons and glial cells** that function as support cells.
- These neurons sense stimuli and transmit electrical signals throughout the animal body.
- Neurons connect to other neurons to send signals. The dendrite is the part of the neuron that receives impulses from other neurons while the axon is the part where the impulse is transmitted to other neurons.
 - o **Neurons** - These are the structural and functional unit of nervous system. It comprises an axon, cell body and dendrites.
 - o **Neuroglia** - These are special cells found in the brain and spinal cord.

They provide support to the neurons and fibres.

- o **Neurosecretory Cells** - These function as endocrine organs. They release chemical from the axons directly into blood.

PLANT TISSUES

Plant tissues are groups of cells that are similar in their origin and their structure and perform similar functions. They are a collection of similar cells that perform organized functions for their plants. They are specialized for a unique purpose, and they can be combined with other tissues creating organs like flowers, stems, leaves, roots, etc. There are also different types of tissues, including meristematic and permanent tissues.

1. MERISTEMATIC TISSUES

- These tissues **can divide and re-divide**, forming new cells through the process of mitotic cell division.
- These newly formed cells will be like the parent cells, but they start to differentiate when they grow, and their **characteristics keep changing**.
- They **assist in the major growth** of the vegetation through growth in length and diameter.
- The cells of meristematic tissues have a **thin primary cell wall** made up of cellulose. Each cell also has a dense cytoplasm and a nucleus with few vacuoles.
- They are generally **oval, rectangular, or polygonal** in shapes.

APICAL - These occur at the *growing tips and apicals of roots and stems*. They raise the *length* of the plant.

INTERCALARY - They occur at the *internodes and basis of leaves*. They raise the *size* of the internode.

LATERAL - These occur in the *radial parts of the stems and roots*. They increase the *thickness* of plants.

2. PERMANENT TISSUES

- These are a group of living or dead cells usually **formed by the meristematic tissues**. They generally **lose their ability to divide**, thus becoming permanent tissues.
- They are **matured meristematic cells**. As they have lost their ability to divide, they take up permanent shapes, sizes, places, etc. This process of **taking up the permanent shape, size**, etc., is called **cellular differentiation**. There are two types of permanent tissues: simple permanent tissues and complex permanent tissues

Simple Permanent Tissues

1. Parenchyma

- These tissues are composed of thin-walled cells having large vacuoles. The cells are loosely packed, and intercellular spaces are quite evident in these types of cells.
- They are generally isodiametric in shape. These tissues provide support to the plants and store food.
- They are found in non-woody and soft parts of stems, roots, flowers, fruits, etc.

2. Collenchyma

- They are elongated living cells with minute little intercellular gaps. Their cell walls are made up of pectin and cellulose.
- They provide flexibility with structural frameworks and also mechanical support to the plants.
- They are found in the marginal sections of the stems and leaves.

3. Sclerenchyma

- They are long, narrow, and thick-walled because of lignin deposition in their cell wall.
- They do not have any intercellular gap.
- Their main function is to provide strength to the plants.
- They are generally found in the veins of leaves, vascular tissues of stems, etc.

Complex Permanent Tissues

- These tissues are made up of more than one type of cell with a common origin and work together to perform similar functions.
- They help transport mineral nutrients, organic food material solutes, water, etc. Hence, they are also known as conducting and vascular tissues.

1. Xylem

- This tissue helps to transport all dissolved substances and water throughout the plant. It is also called the chief conducting tissue.
- These tissues are organized in a tubular fashion throughout the main axis of stems and roots. The various components of the xylem included: vessels, tracheids, xylem fibers, parenchyma, etc. Most of the conduction here is vertical, but lateral conduction occurs through the rays, which are horizontal rows of long parenchyma cells.

2. Phloem

- It is also called the plant's plumbing system. They carry the dissolved food substances throughout the plant. The conduction system comprises sieve tubes, companion cells, and secondary walls. The various components of phloem included: sieve tubes, phloem fibers, companion cells, and phloem parenchyma.

Protective Tissues

- The last type of plant tissue is protective tissues, and they provide support and fortification to plants.

1. Cork

- It is an external type of protective tissue.
- These cells are lifeless and lack intercellular gaps.
- The walls of the cells are coagulated with suberin.
- The main function of suberin is it makes the plant impervious to gas and other water molecules.

2. Epidermis

- This is a cell made up of an outer casing throughout the structure of the plants.
- The stomata merge with this layer at certain places.

CELL MODIFICATIONS

- These are **specialized** cell structures or modifications **re-acquired by the cell after cell division** that helps the cell in different ways.
- It is an actual process that occurs after cell division where the newly-formed cells are structurally modified so that they can perform their function efficiently and effectively.

APICAL MODIFICATIONS

- Cell modification **found on the apical surface** of the cell.
- It is specialized to carry out functions that occur at these interfaces, including **secretion, absorption, and movement of luminal** contents.

1. Cilia and Flagella

- Cilia are projections, usually short, hair like structures and a type of organelle seen on the apical surface of epithelial cells. This assists in the movement of material over the epithelial surface in a manner parallel with the surface of the epithelium.
- Flagella are long, whip-like structure that are formed by microtubules protruding from the cell body of bacteria and some eukaryotic cells.

2. Villi and Microvilli

- Villi are finger-like projections that arise from the epithelial layer in some organs.
- They help to increase surface area, allowing faster and more efficient absorption.
- Microvilli are smaller projections than villi which functions primarily on the efficient absorption of molecules.

3. Pseudopods

- Temporary, irregular lobes formed by amoebas and some other eukaryotic cells. It bulges outward to move the cell or engulf the prey.

- It primarily consist of actin filaments and may also contain microtubules and intermediate filaments.
- Pseudopods are used for motility and ingestion.

4. Extra Cellular Matrix (ECM)

- Most animal cells release materials into the extracellular space, creating a complex meshwork of proteins and carbohydrates called ECM.
- A major component of the extracellular matrix is the protein collagen. Collagen proteins are modified with carbohydrates, and once they're released from the cell, they assemble into long fibers called collagen fibrils
- In the extracellular matrix, collagen fibers are interwoven with a class of carbohydrate-bearing proteoglycans, which may be attached to a long polysaccharide backbone. The extracellular matrix also contains many other types of proteins and carbohydrates.

BASAL MODIFICATIONS

- Cell modification **found on the basal surface** of the **cell basement** membrane.

1. Hemidesmosomes

- These allow for strong attachment between cells or to a basement membrane.
- Desmosomes attach to the microfilaments of cytoskeleton made up of keratin protein.
- hemidesmosomes are similar to desmosomes in terms of function, however, they attach the epithelial cell to the basement membrane rather than the adjacent cell.

LATERAL MODIFICATIONS

- Cell modification **found on the sideways** of the cell.
- These structures consist of **protein complexes and induce connectivity between adjacent epithelial cells, between cells and ECM.**

- They can contribute to the **barrier function** of epithelia and control paracellular **transport**.

1. Tight Junctions

- Also called zonula occludens (or occluding junctions) are a type of cell junction characterized by forming an adhesion complex between two neighboring cells serving as a tight seal between the cells.
- Being tightly packed, tight junctions serve as barriers for pathogens, mechanical injuries, and fluid loss.

2. Adherens Junctions

- Protein complexes that occur in cell to cell junctions in epithelial and endothelial tissues, usually more basal than tight junctions.
- It fastens cell to one another.

3. Gap Junctions

- It is also known as communicating junctions
- These are specialized intercellular connections between multitude of animal cell-types.
- They directly connect the cytoplasm of two cells, which allows various molecules, ions and electrical impulses to directly pass through a regulated gate between cells.

CELL CYCLE AND CELL DIVISION

- In **1858** the pathologist **Rudolph Virchow** coined the **cell doctrine** which states that **"When a cell arises, there must have been a previous cell, just as animals can only arise from animals and plants from plants."** This doctrine is founded on the understanding that whether one is examining a single-celled organism or an animal as complex as man, the product is a result of repeated rounds of cell growth and division.
- Most eukaryotic cells will proceed through an ordered series of events in which the cell duplicates its contents and then divides into two cells. This cycle of

duplication and division is called the cell cycle.

- In order to maintain the fidelity of the developing organism this process of cell division in multicellular organisms must be highly ordered and tightly regulated. The loss of control will lead to abnormal development and is the cause of cancer.

Why do cell divides?

- In unicellular organisms, cell division reproduces an entire organism (e.g. paramecium).
- In multicellular organisms, cell division is the basis for growth and development from the fertilized egg and replacement of damaged or dead cells

The Cell Cycle

- The cell cycle is **a series of events that lead to cell division**. It consists of four phases: **G1, S, G2 and M**, where **"G" stands for "gap", "S" represents "synthesis" and "M" means "mitosis"**. A newly divided cell may either enter into another round of cell division or remain in the resting state for a long period of time. **In the latter case, the cell is said to be in the G0 phase**. Upon specific stimulation, cells in the **G0 phase may re-enter the G1 phase**.
- The process of cell division is more straightforward in lower, single-celled (prokaryotes) organisms than higher multicellular (eukaryotes) ones. The reason is that a prokaryotic cell has a relatively simpler cell organization with a single circular chromosome, absence of a nucleus, and few cell organelles. In contrast, eukaryotic cells have multiple chromosomes present within a nucleus and various organelles.
- A **eukaryotic cell cycle** consists of two main parts: **1) interphase and 2) mitotic (M) phase, and an alternative part called the G0-phase**.

PHASES OF CELL CYCLE

1. Interphase

- **G1 phase**
 - o During G1, the cell reviews the cellular environment and the cell size to

ensure that the conditions are appropriate to support DNA replication. Not until the cell is ready does it leave G1. If all is not ready to undergo DNA replication, cells can pause during G1 and enter a phase called G0.

- o Depending on a cell's preparedness to continue in the cell cycle, G0 can last days, weeks, or even years. When the cell has reached an appropriate size and is in a supportive environment for DNA replication, it will exit either G1 or G0 and enter the next phase of interphase called S phase.
- o The cell grows in preparation for DNA replication, and certain intracellular components, such as the centrosomes undergo replication. Before a cell begins DNA replication, it must ensure that it is biologically ready to take on such a process. There is a major check-point in a normal cell cycle that is critical for ensuring that all is well for the cell to enter S-phase.

S phase

- During S phase a number of events additional to chromosome replication take place. Cell growth continues through S phase, as does the rate of synthesis of a number of proteins and enzymes that are involved in DNA synthesis.
- Once DNA replication is complete the cell contains twice its normal number of chromosomes and becomes ready to enter the phase called G2.

G2 phase

- Similar to G1, G2 is an intermediate phase, a time for the cell to ensure that it is ready to proceed in the cell cycle.
- Occurring between the end of DNA replication in S phase and the beginning of cell division in mitosis, G2 can be thought of as a safety gap during which a cell can check to make sure that the entirety of its DNA and other intracellular components have been properly duplicated.
- In addition to acting as a checkpoint along the cell cycle, G2 also represents

the cell's final chance to grow before it is split into two independent cells during mitosis.

G0 Phase

- Not all cells adhere to the classic cell cycle pattern in which a newly-formed daughter cell immediately enters the preparatory phases of interphase, closely followed by the mitotic phase.
- Cells in G0 phase are not actively preparing to divide. The cell is in a quiescent (inactive) stage that occurs when cells exit the cell cycle.
- Some cells enter G0 temporarily until an external signal triggers the onset of G1. Other cells that never or rarely divide, such as mature cardiac muscle and nerve cells, remain in G0 permanently.

Checkpoints and Cell Cycle Regulation

A checkpoint is a stage in the eukaryotic cell cycle at which the **cell examines internal and external cues and "decides" whether or not to move forward** with division.

The cell cycle is controlled at three checkpoints. The integrity of the DNA is assessed at the G1 checkpoint. Proper chromosome duplication is assessed at the G2 checkpoint. Attachment of each kinetochore to a spindle fiber is assessed at the M checkpoint.

G1-checkpoint

- Present just before the entry into S-phase, it makes the critical decision whether the cell will enter the S-phase
- At the G1 checkpoint, a cell checks whether internal and external conditions are right for division. Here are some of the factors a cell might assess:
 - o **Size.** Is the cell large enough to divide?
 - o **Nutrients.** Does the cell have enough energy reserves or available nutrients to divide?
 - o **Molecular signals.** Is the cell receiving positive cues (such as growth factors) from neighbors?
 - o **DNA integrity.** Is any of the DNA damaged?

G2-checkpoint

- **DNA integrity.** Is any of the DNA damaged?
- **DNA replication.** Was the DNA completely copied during S phase?

M checkpoint

- The M checkpoint is also known as the spindle checkpoint: here, the cell examines whether all the sister chromatids are correctly attached to the spindle microtubules.
- Because the separation of the sister chromatids during anaphase is an irreversible step, the cycle will not proceed until all the chromosomes are firmly attached to at least two spindle fibers from opposite poles of the cell.

How does this checkpoint work?

- It seems that cells don't actually scan the metaphase plate to confirm that all of the chromosomes are there. Instead, they look for "straggler" chromosomes that are in the wrong place (e.g., floating around in the cytoplasm) If a chromosome is misplaced, the cell will pause mitosis, allowing time for the spindle to capture the stray chromosome.

How do the checkpoints actually work?

- Internal and external cues trigger signaling pathways inside the cell that activate, or inactivate, a set of core proteins that move the cell cycle forward.
- Regulator molecules may act individually, or they can influence the activity or production of other regulatory proteins. Therefore, the failure of a single regulator may have almost no effect on the cell cycle, especially if more than one mechanism controls the same event. Conversely, the effect of a deficient or non-functioning regulator can be wide-ranging and possibly fatal to the cell if multiple processes are affected.
- Control of the cell cycle is necessary for a couple of reasons. First, if the cell cycle were not regulated, cells could constantly undergo cell division. While this may be beneficial to certain cells, on the whole

constant reproduction without cause would be biologically wasteful. Second, internal regulation of the cell cycle is necessary to signal passage from

- one phase to the next at appropriate times. This regulation is not achieved through strict time constraints, but rather with feedback from the cell.

Positive Regulation - *promote progress of the cell to the next phase*

Negative Regulation - *halt the cycle*

POSITIVE REGULATION

- Two groups of proteins, called cyclins and cyclin-dependent kinases (Cdks), are responsible for the progress of the cell through the various checkpoints. The levels of the four cyclin proteins fluctuate throughout the cell cycle in a predictable pattern. Increases in the concentration of cyclin proteins are triggered by both external and internal signals. After the cell moves to the next stage of the cell cycle, the cyclins that were active in the previous stage are degraded.
- DNA replication and mitosis are dependent on the activity of cyclin-dependent protein kinase (CDK) enzymes, which are heterodimers of a catalytic subunit with a cyclin subunit.

Cyclin-Dependent Protein Kinase (Cdks)

- A Cdk is an enzyme that adds negatively charged phosphate groups to other molecules in a process called phosphorylation. Through phosphorylation, Cdks signal the cell that it is ready to pass into the next stage of the cell cycle. As their name suggests, Cyclin-Dependent Protein Kinases are dependent on cyclins, another class of regulatory proteins. Cyclins bind to Cdks, activating the Cdks to phosphorylate other molecules.

Cyclins

- Cyclins are named such because they undergo a constant cycle of synthesis and degradation during cell division. When cyclins are synthesized, they act as an activating protein and bind to Cdks

forming a cyclin-Cdk complex. This complex then acts as a signal to the cell to pass to the next cell cycle phase.

- Eventually, the cyclin degrades, deactivating the Cdk, thus signaling exit from a particular phase. There are two classes of cyclins: mitotic cyclins and G1 cyclins.
- Cyclins activate cyclin dependent kinases (CDKs), which control cell cycle processes through phosphorylation.
- When a cyclin and CDK form a complex, the complex will bind to a target protein and modify it via phosphorylation.
- The phosphorylated target protein will trigger some specific event within the cell cycle (e.g. centrosome duplication, etc.)
- After the event has occurred, the cyclin is degraded and the CDK is rendered inactive again.

NEGATIVE REGULATION

Retinoblastoma Protein (Rb), p53, and p21

- Retinoblastoma proteins are a group of tumor-suppressor proteins common in many cells. The 53 and 21 designations refer to the functional molecular masses of the proteins (p) in kilodaltons.

How long does the cell cycle take?

- Different cells take different lengths of time to complete the cell cycle.
- A typical human cell might take about 24 hours to divide, but fast-cycling mammalian cells, like the ones that line the intestine, can complete a cycle every 9-10 hours when they're grown in culture

MITOSIS

Mitosis is a fundamental process for life. During mitosis, a **cell duplicates all of its contents, including its chromosomes, and splits to form two identical daughter cells**. Because this process is so critical, the steps of mitosis are carefully controlled by a number of genes. When mitosis is not regulated correctly, health problems such as cancer can result.

4 Stages of Mitosis

1. Prophase
2. Metaphase
3. Anaphase
4. Telophase

1. Prophase

- Chromosomal material condenses to form compact mitotic chromosomes. Chromosomes are seen to be composed of two chromatids attached together at the centromere.
- Initiation of the assembly of mitotic spindle, the microtubules, the proteinaceous components of the cell cytoplasm help in the process.

2. Metaphase

- Spindle fibres attach to kinetochores of chromosomes.
- Chromosomes are moved to spindle equator and get aligned along metaphase plate through spindle fibres to both poles

3. Anaphase

- Centromeres split and chromatids separate.
- Chromatids move to opposite poles.

4. Telophase

- Chromosomes cluster at opposite spindle poles and their identity is lost as discrete elements.
- Nuclear envelope assembles around the chromosome clusters.
- Nucleolus, golgi complex and ER reform.

Cytokineses

- Cytokinesis is the process by which the cell divides into two daughter cells.
- In animal cells, a contractile ring of actin and myosin filaments forms around the cell, contracting and pinching the cell membrane until the cell is divided into two separate cells.
- In plant cells, a structure called the cell plate forms along the equator of the cell, eventually dividing the cell into two separate daughter cells.

OTHER INFORMATION:

- Cell Division - Mitosis

Division of a somatic cell that **results in 2 genetically identical daughter cells**

- Cells must divide for **growth, repair of tissues, and asexual reproduction**
- **Cell division begins in interphase** when the chromosomes duplicate
- **Daughter cells are genetically identical to parent cell** – same kind and number of chromosomes
- **Mitosis occurs in somatic or body cells** (Ex: liver, heart, skin, stomach)
- Every organism has its own unique number of chromosomes. **Humans have 46 chromosomes.**
- This is called its **diploid number** or the **total number of chromosomes** in a somatic cell.
- **Diploid** means “**2 sets**” and is written as “**2n**”

MEIOSIS

- Meiosis **reduces the number of chromosome** sets from **diploid to haploid**
- Meiosis is the process by which a **single cell divides into four daughter cells**, each with half the number of chromosomes of the parent cell. Meiosis is critical for sexual reproduction, as it allows for the production of gametes.
- Meiosis takes place in two sets of divisions
- Meiosis I reduces the number of chromosomes from diploid to haploid
- **Meiosis II produces four haploid daughter cells**
- Meiosis involves the **same four phases seen in mitosis**
- They are repeated during both meiosis I and meiosis II.
- The period of time **between meiosis I and meiosis II** is called **interkinesis**.
- **No replication of DNA occurs during interkinesis** because the DNA is already duplicated.
- **Meiosis produces sex cells** – cells with $\frac{1}{2}$ the number of chromosomes as the original cell
- **Males** – meiosis produces **4 sperm**
- **Females** – meiosis produces **1 (viable) egg**

- The other 3 cells are called polar bodies – they give up their cytoplasm to nourish the 1 good egg.
- **Egg and sperm** (sex cells) are also called **gametes**
- **Gametes have** $\frac{1}{2}$ the number of chromosomes as somatic (body) cells. We call this the haploid number. **Haploid** means “**1 set**” and is written as “**N**”
- If human diploid number is 46, what is its haploid number? 23
- **Diploid # of a dog - 78, Haploid # of a dog - 39**
- **Diploid # of a fly - 8, Haploid # of a fly - 4**

When does meiosis occur in humans?

- Males beginning at puberty
- Females before birth – all eggs are produced before birth and at puberty eggs mature

MEIOSIS I

1. Prophase I

- Chromosomes begin to condense
- In synapsis, the 2 members of each homologous pair of chromosomes line up side-by-side, aligned gene by gene, to form a tetrad consisting of 4 chromatids
- During synapsis, sometimes there is an exchange of homologous parts between nonsister chromatids. This exchange is called crossing over
- Each tetrad usually has one or more chiasmata, X-shaped regions where crossing over occurred

2. Metaphase I

- At metaphase I, tetrads line up at the metaphase plate, with one chromosome facing each pole
- Microtubules from one pole are attached to the kinetochore of one chromosome of each tetrad
- Microtubules from the other pole are attached to the kinetochore of the other chromosome

3. Anaphase I

- In anaphase I, pairs of homologous chromosomes separate

- One chromosome moves toward each pole, guided by the spindle apparatus
- Sister chromatids remain attached at the centromere and move as one unit toward the pole.

4. Telophase I

- During telophase I, the chromosomes are enclosed in nuclei. The cell now undergoes a
- process called cytokinesis that divides the cytoplasm of the original cell into two daughter
- cells. Each daughter cell is haploid and has only one set of chromosomes, or half the total number of chromosomes of the original cell.

MEIOSIS II

5. Prophase II

- Meiosis II is very similar to mitosis
- In prophase II, a spindle apparatus forms
- In late prophase II, chromosomes (each still composed of two chromatids) move toward the metaphase plate.

6. Metaphase II

- At metaphase II, the sister chromatids are at the metaphase plate.
- Because of crossing over in meiosis I, the two sister chromatids of each chromosome are no longer genetically identical.
- The kinetochores of sister chromatids attach to microtubules extending from opposite poles.

7. Anaphase II

- At anaphase II, the sister chromatids separate
- The sister chromatids of each chromosome now move as two newly individual chromosomes toward opposite poles.

8. Telophase II

- In telophase II, the chromosomes arrive at opposite poles
- Nuclei form, and the chromosomes begin decondensing
- Cytokinesis separates the cytoplasm

- At the end of meiosis, there are four daughter cells, each with a haploid set of unreplicated chromosomes
- Each daughter cell is genetically distinct from the others and from the parent cell

The advantage of meiotic division and sexual reproduction is that it promotes genetic variation in offspring.

The **three main sources of genetic variation** arising from sexual reproduction are:

1. Crossing over (in prophase I)

- Crossing over involves the exchange of segments of DNA between homologous chromosomes during prophase I
- The exchange of genetic material occurs between non-sister chromatids at points called chiasmata
- As a consequence of this recombination, all four chromatids that comprise the bivalent will be genetically different
- Chromatids that consist of a combination of DNA derived from both homologous chromosomes are called recombinants
- Offspring with recombinant chromosomes will have unique gene combinations that are not present in either parent

2. Random assortment of chromosomes (in metaphase I)

- When homologous chromosomes line up in metaphase I, their orientation towards the opposing poles is random,
- The orientation of each bivalent occurs independently, meaning different combinations of maternal / paternal chromosomes can be inherited when bivalents separate in anaphase I.
- The total number of combinations that can occur in gametes is 2^n – where n = haploid number of chromosomes.
- Humans have 46 chromosomes ($n = 23$) and thus can produce 8,388,608 different gametes (2^{23}) by random orientation.
- If crossing over also occurs, the number of different gamete combinations becomes immeasurable.

3. Random fusion of gametes from different parents

- The fusion of two haploid gametes results in the formation of a diploid zygote.
- This zygote can then divide by mitosis and differentiate to form a developing embryo.
- As meiosis results in genetically distinct gametes, random fertilization by egg and sperm will always generate different zygotes.
- Identical twins are formed after fertilization, by the complete fission of the zygote into two separate cell masses.

Fertilization – process by which an egg and sperm unite to form a zygote

Zygote – fertilized egg

Embryo – organism in early stage of development

Chromosome Number

- Remember, chromosome number is unique to each kind of organism and all cells (except sex cells) in an organism have the same kind and number of chromosomes.
- Ex: All humans have 46 chromosomes and all cells in the human body (except sperm and egg) have 46 chromosomes.
- This is why the chromosome number in sex cells must be reduced in half by meiosis
- Ex: Humans have 46 chromosomes in their somatic cells, but 23 chromosomes in their sex cells (egg and sperm)

Homologous chromosomes

- Are paired chromosomes with genes for the same trait arranged in the same order. Ex. Eye color, hair color, height, one may code for blue, blonde, tall, its homolog may code for brown, blonde, short
- Homologous chromosomes may have different alleles on them
 - Allele- gene form for each variation of a trait of an organism

4 MEDICAL CONDITIONS

- a. Tumors that developed into cancer
- b. Aneuploidy
- c. Alzheimer's disease
- d. Anemia

1. Organic compound that cannot be found in all membrane?

- Nucleic acids (DNA and RNA) are organic compounds that are not typically found in all cellular membranes. Membranes are mainly composed of lipids (like phospholipids), proteins, and carbohydrates.

2. Mitosis are significant except for?

- Formation of gametes (in sexual reproduction). Mitosis is not involved in the production of gametes; meiosis is the process responsible for gamete formation.

3. Where does desmosomes attach?

- Desmosomes attach to the microfilaments of cytoskeleton made up of keratin protein.
 - Hemidesmosomes are similar to desmosomes in terms of function, however, they attach the epithelial cell to the basement membrane rather than the adjacent cell.

4. What type of tissue organic mineral?

- Mineralized Tissue: Bone tissue is an example of tissue that contains organic minerals. The matrix of bone tissue is a combination of organic materials (mainly collagen) and inorganic minerals (like calcium phosphate).

5. This are negative regulators except?

- Growth factors are not negative regulators, while tumor suppressor proteins, CDK inhibitors, and other factors often act as negative regulators in cell cycle control.

6. Which statement are not true about cell modification?

- Cells do not change after differentiation

7. Contribution of Robert Hooke?

- Robert Hooke is credited with the discovery of cells in 1665. He observed the structure of cork under a microscope and coined the term "cell" to describe the small, box-like structures he saw.